



### Weekly Seminar

## Nonreciprocal electric responses in superconductors

# Youichi Yanase

Kyoto University

**Time: 3:00pm, June. 8, 2022 (Wednesday)**

**时间: 2022年6月8日 (周三) 下午3:00**

**腾讯会议链接: <https://meeting.tencent.com/dm/8no8Ovbctw3E>**

**腾讯会议ID: 842-941-801**

### Abstract

We show theoretical framework of various nonreciprocal responses in superconductors. The superconducting diode effect, nonlinear superconducting optics, and nonreciprocal Meissner effect are studied, and observation in parity-breaking superconductors is proposed.

First, stimulated by the recent experiment [1], we propose an intrinsic mechanism to cause the superconducting diode effect (SDE) [2]. SDE refers to the nonreciprocity of the critical current. We clarify that the SDE is understood by the nonreciprocity of the Landau critical momentum and the change in the nature of the helical superconductivity. The intrinsic SDE unveils the rich phase diagram and functionalities of noncentrosymmetric superconductors.

Second, we show that superconductors with the space-inversion symmetry breaking host giant nonreciprocal optical responses, such as photocurrent generation and second harmonic generation [3]. Divergent behaviors are attributed to the nonreciprocal superfluid density and the Berry curvature derivative, characteristic of parity-breaking superconductors. These indicators quantify the performance of superconductors in nonlinear optics.

The nonreciprocal correction to the superfluid density also leads to the nonreciprocal Meissner effect, namely, asymmetric screening of magnetic fields due to the nonreciprocal magnetic penetration depth. Performing a microscopic analysis of an exotic superconductor  $UTe_2$ , we show that the nonreciprocal Meissner effect is useful to probing parity-mixing properties and gap structures in superconductors [4].

#### References:

1. F. Ando, Y. Miyasaka, T. Li, J. Ishizuka, T. Arakawa, Y. Shiota, T. Moriyama, Y. Yanase, and T. Ono, *Nature* **584**, 373 (2020).
2. Akito Daido, Yuhei Ikeda, Youichi Yanase, *Phys. Rev. Lett.* **128**, 037001 (2022)
3. Hikaru Watanabe, Akito Daido, Youichi Yanase, *Phys. Rev. B* **105**, 024308 (2022)
4. Hikaru Watanabe, Akito Daido, Youichi Yanase, *Phys. Rev. B* **105**, L100504 (2022).

### About the speaker

Dr. Youichi Yanase is a professor in Department of Physics and Astronomy in Kyoto University. After his graduate study in Kyoto University, he worked as a research associate (later an assistant professor) in the University of Tokyo (2000-2009), as an associate professor in Niigata University (2009-2015), as an associate professor in Kyoto University (2015-2019). Since 2019, he has been a full professor. He earned PhD from Kyoto University in 2001 and he was also a guest researcher in ETH (2006 - 2007). He has been working on theories of strongly correlated electron systems, random fermions, ultracold atoms, and topological states of matters. He is well-known for his contributions to microscopic theories of unconventional superconductors (high- $T_c$  cuprates, transition metal oxides, and heavy fermions). He was granted as young researcher award from physical society of Japan (division 8) (2011) and as an outstanding paper award of the physical society of Japan (2013).